

Variation in egg production of *Pityohyphantes phrygianus* (C.L. Koch) (Linyphiidae, Aranaeae), influenced by temperature and latitude

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Variation in egg production of *Pityohyphantes phrygianus* (C.L. Koch) (Linyphiidae, Aranaeae), influenced by temperature and latitude. - The effects of temperature and geographic origin on the production of eggs and egg sacs of female *Pityohyphantes phrygianus* (C. L. Koch) were examined in a laboratory experiment. Subadults of three populations, 160 - 800 km apart, were sampled and the spiders were raised to maturity and mated. The females were then kept at 10°, 15° and 20°C, respectively. The egg sacs were removed from the cages and the egg mass was weighed. Females reared at the highest temperature produced, on average, twice as many egg sacs, had a 50% reduction of the reproductive life span and put 50% less egg mass in each egg sac compared to females reared at the lowest temperature. In spite of these differences, the total mass of eggs produced was similar for all temperatures and populations except for the females of the northernmost population in the highest temperature (20°C). The females of this group on average died earlier when reared at the highest temperature and could not produce more egg sacs than in lower temperatures. This suggests that genetic or prereproductive environmental factors affect the plasticity of the female reproduction.

Key-words: egg production-temperature-environmental factor-reproduction.

INTRODUCTION

The spider *Pityohyphantes phrygianus* (C. L. Koch) is widespread in boreal areas in Scandinavia. When different populations of the same species occur in areas with large environmental differences such as different average ambient temperature or seasonal length, one can expect that a reaction norm exists for traits important to fitness. A reaction norm is the phenotypic or plastic response of a genotype along an environmental gradient (STEARNS 1989). Differences between populations in their

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plastic response to environmental factors may be due to genetic constraints, preventing the development of an optimal response for all environments (THOMPSON 1991).

The effect of temperature and geographic origin on the following population parameters has been tested in a laboratory experiment: Number of egg sacs produced, egg mass per egg sac, total mass of eggs, time until first oviposition and total reproductive lifespan.

MATERIAL AND METHODS

I collected subadult ♂♂ and ♀♀ of the sheet-web spider *P. phrygianns* in March and April 1993 from three populations in forests of spruce (*Picea abies*); **A**) Härskogen, 30 km east of Göteborg (UTM: 64 03 80, 3 24 150); **B**) Snapen, 10 km north of Mariestad (UTM: 65 11 25, 4 34 400 and **C**) Vassnäs, 110 km west of Östersund (UTM: 70 51 20, 4 02 200). The spiders were reared to maturity in 500 ml plastic jars under constant laboratory conditions. The temperature was kept at 20°C and each spider was supplied with equal amounts of food (about 10 flies/week), *i.e.* vestigial-winged fruit flies (*Drosophila melanogaster*). This feeding regime was kept throughout the experiment. After maturity the ♀♀ were randomly paired with one male from the same population when enough males were available. In seven cases for population **A** and three cases for population **C**, males from population **B** had to be used instead of males from populations **A** and **C**, respectively. When the male populations of origin were used in the Kruskal-Wallis test, the number of eggs produced showed no correlation with the male origin, so male populations were left out in the final analysis. The ♀♀ were then assigned to three different temperatures, 10°C, 15°C and 20°C in which they were kept until they died. The jars were checked every other day and egg sacs were removed, to count and weigh the eggs. In about 10 % of the clutches the eggs were "glued" together and could not be counted. No differences were found in the average mass per egg from different clutches in those clutches that could be counted. I therefore used egg mass as a measure of egg production. Twelve spiders (22,2 %) that did not produce any egg sacs before death were not included in the analysis.

All data were analysed with Kruskal-Wallis non-parametric ANOVA for three or more groups using StatView 4.02 for Macintosh. All p-values given are from this test. To determine which groups being significantly different, I used the method of multiple comparisons between treatments in the Kruskal-Wallis test (SIEGEL & CASTELLAN 1988).

RESULTS

When the populations were pooled the egg mass per egg sac decreased with increasing temperature ($p=0,0147$). When the populations were tested separately, however, none of the populations showed a significant decrease (fig 1), probably due to the low sample size. The average egg mass/egg sac in population **A** decreased from

6.9 mg at 10°C to 3.4 mg at 20° ($p=0.1141$) and in population C from 11.0 mg at 10°C to 5.0 mg at 20°C ($p=0.0804$). In population B the average egg mass/eggsac were more similar between temperatures, ranging from 4.6 mg at 10°C to 3.1 mg at 20°C ($p=0.3229$). No significant differences were found between populations, even when temperatures were pooled ($p=0.1487$).

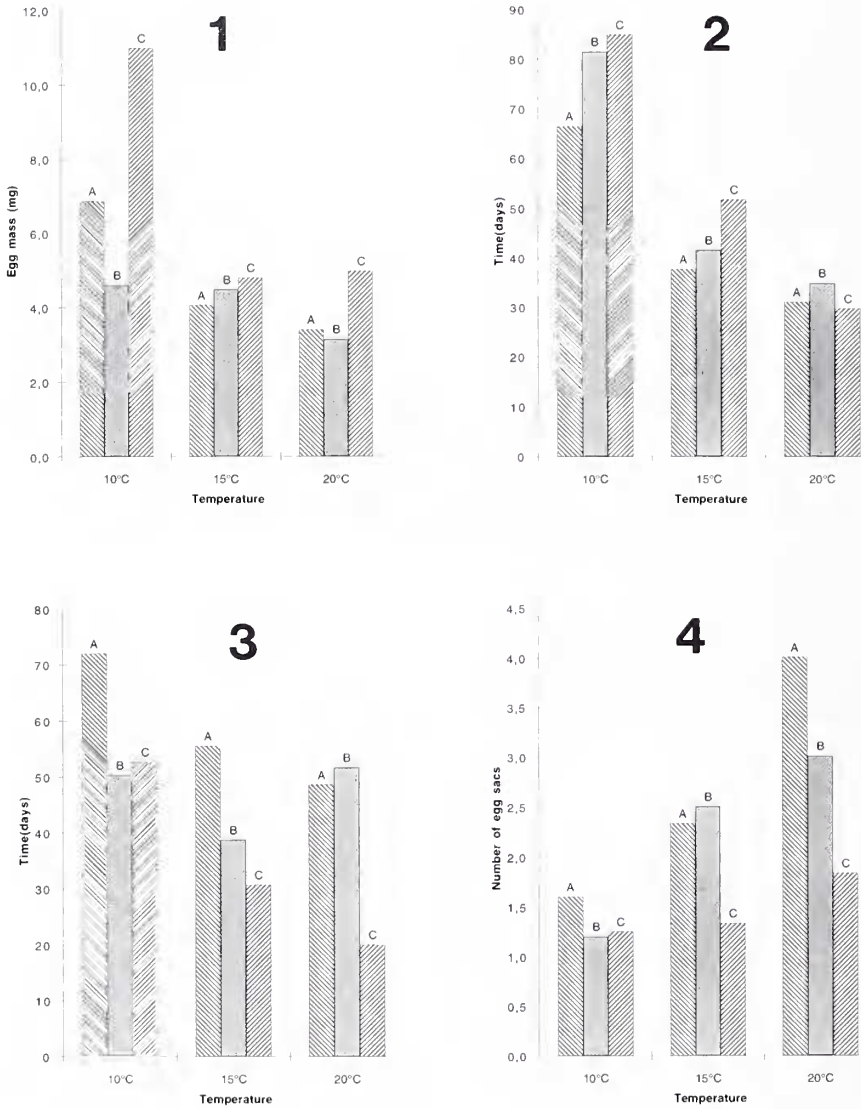
The average time from the start of the experiment to first reproduction (i.e. production of first egg sac) decreased significantly with increasing temperature (fig.2) for all populations. In population A the average time decreased from 66.4 days in 10°C to 31.0 days in 20°C ($p=0.0024$). In population B from 81.4 days in 10°C to 34.8 days in 20°C ($p=0.0079$) and in population C from 84.8 days in 10°C to 29.7 days in 20°C ($p=0.0264$).

The ♀♀ of the northern population C seemed to suffer disproportionately from high temperature, since they had a shorter average reproductive lifespan (fig.3) in 20°C (20.0 days) than in 10°C (52.7 days), while ♀♀ of the two other populations seemed unaffected by temperature. Population C had a significantly shorter reproductive lifespan compared to the other populations when temperature groups were pooled ($p=0.0191$). But this difference between populations is not consistent across the temperature interval. The reproductive lifespan of the population C at 20°C was significantly shorter than for the other populations ($p=0.0149$). It was also shorter, but not significantly so, at 15°C ($p=0.1163$), whereas at 10°C population C was intermediate between populations A and B and no significant differences in the reproductive lifespan could be observed ($p=0.7216$). As a result of this the ♀♀ of the northern population C produce fewer clutches in 20°C than populations A and B ($P = 0.0198$) whereas in lower temperatures the number of clutches do not differ between populations (fig.4).

DISCUSSION

The general results shown in this study can be interpreted as a behavioural reaction norm to differences in ambient temperature. *Pityohyphantes phrygianus* matures, mates and produce offspring in early spring and if the earliest developmental stages are sensitive to cold temperature, then ♀♀ should delay their oviposition as much as possible in low temperatures to ensure their progeny a better environment for development. On the other hand, when experiencing high temperatures, ♀♀ risk that it is late in the season so their progeny's development before winter becomes too short and therefore they should produce egg sacs as quickly as possible. The result of this study is qualitatively similar to the result in a study by DOWNES (1988) on *Theridion rufipes* Lucas. Downes concluded that at the temperature where no embryos developed, ♀♀ delayed their first oviposition and extended their oviposition intervals significantly.

Egg mass per egg sac also decreases with temperature, but this, I suggest, is depending on the decreasing time between ovipositions when temperature increases. It has previously been shown that for spiders clutch weight is linearly dependent on



FIGS 1-4

Fig. 1. Average eggmass per eggsac. Sample sizes: 10°C: **A** n=4, **B** n=4, **C** n=3; 15°C: **A** n=6, **B** n=6, **C** n=3; 20°C: **A** n=6, **B** n=5, **C** n=5. - Fig. 2. Average time from start of experiment to first reproduction. Sample sizes are the same as in figure 1. - Fig. 3. Average time from first reproduction to first egg production. Sample sizes are the same as in figure 1. - Fig. 4. Average number of egg sacs produced. Sample sizes are the same as in figure 1.

pre-laying weight of the female (HIGGINS 1992) and spider weight is linearly dependent on food consumption (KESSLER 1971; TURNBULL 1962).

The failure of the ♀♀ of the northern population to produce an equal amount of eggs in 20°C as they do in lower temperatures can not be explained within the pattern described above. Considering the shorter summer season and lower average temperatures experienced by spiders in northern populations, one might expect them to do better than the other populations in low temperatures and worse in high temperatures, but no significant differences in the ability to manage with low temperatures were discovered.

I conclude that there is a plastic response in the reproductive behaviour of the female *P. phrygianus* to variations in temperature and that higher temperature shortens the time between egg sacs, which leads to fewer eggs in each sac. I also conclude that ♀♀ from the northern population (C) died earlier at high temperatures, making it impossible to produce more egg sacs than in lower temperatures. There are at least two possible explanations for the pattern observed here, (i) genetic factors are controlling the plastic response and that northern and southern populations differ genetically, or (ii) the response may be triggered by environmental cues during juvenile growth.

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